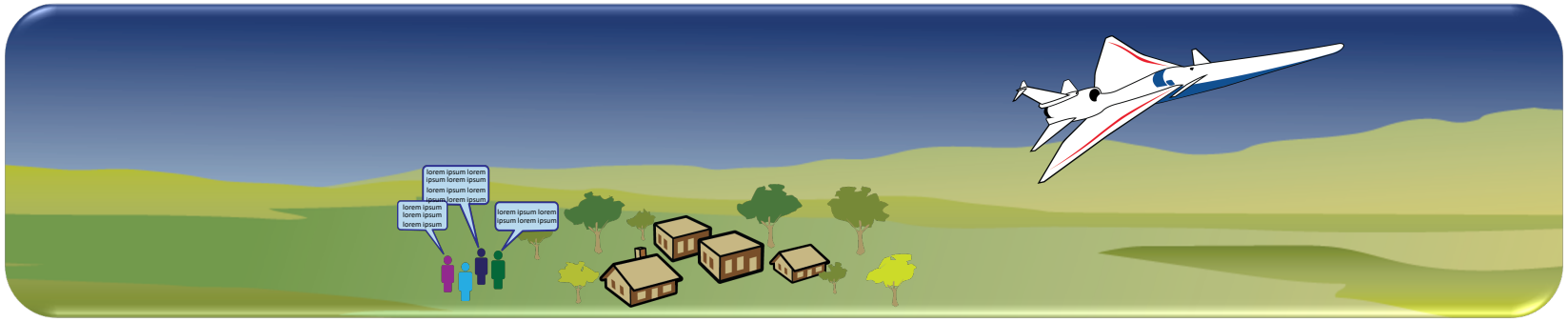


NASA Community Test Workshop 2

Introduction & Workshop Goals

Lori Ozoroski

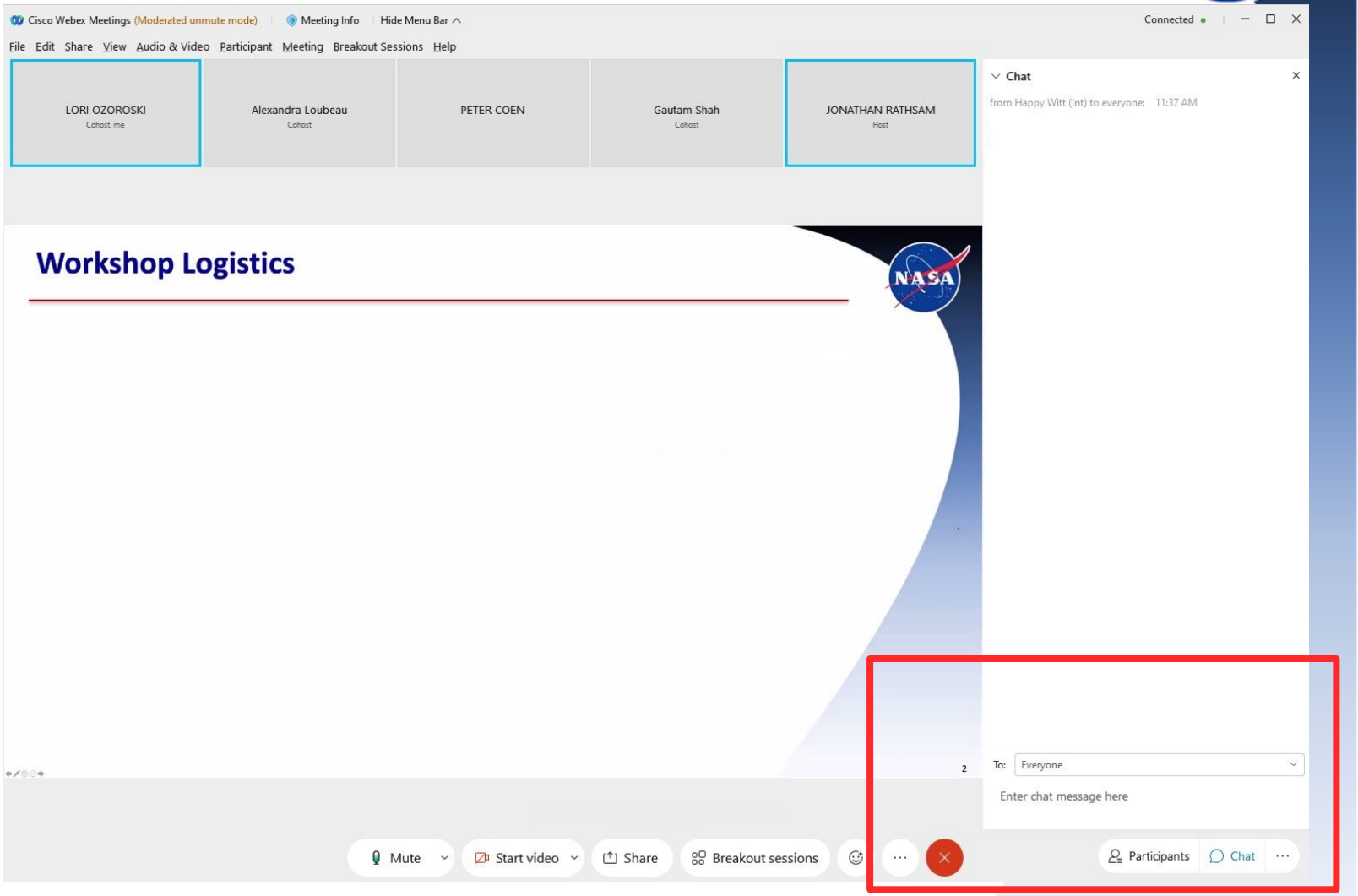
Commercial Supersonic Technology Project Manager

December 13-14, 2021

Workshop Logistics

Logistics/ WebEx Protocol

- Webex sign on information by invitation
- Telecon lines muted during presentation
- Submit questions via WebEx Chat function
  - Hosts will monitor incoming questions for discussion
- Presentation will be recorded and made available at a later date



Speakers

- **Lori Ozoroski** — Project Manager: NASA Commercial Supersonic Technology Project
- **Peter Coen** — Mission Integration Manager: NASA Low Boom Flight Demonstration
- **Gautam Shah** — Sub-Project Manager: Community Test Planning & Execution
- **Sandy Liu** — Aviation Policy, Planning & Environment Engineer, FAA Noise Division
- **Alexandra Loubeau** — Community Test Technical Lead: Noise Exposure Design and Estimation
- **Jonathan Rathsam** — Community Test Technical Lead: Survey Design and Analysis

Workshop Introduction

- **<u>Workshop Focus</u>:**
  Discussion and feedback on plans for conducting surveys and estimating noise exposure levels in community testing

- **Presentation/Discussion Topics:**
  - LBFD mission and community test overviews
  - Technical goals for the community overflight tests, including *<u>anticipated uses and delivery of dose-response data</u>*, both single-event and cumulative
  - Considerations and approaches for ensuring *<u>broad representativeness of results</u>*, including test site selection, community engagement, and participant recruitment
  - Approaches for *<u>estimation of the sonic boom carpet across the test site</u>*, including exposure design and combining of measured and predicted levels
  - Integration of exposure levels with survey results to *<u>define the dose-response relationship</u>*
  - Discussion of feedback received to date

Workshop Goals

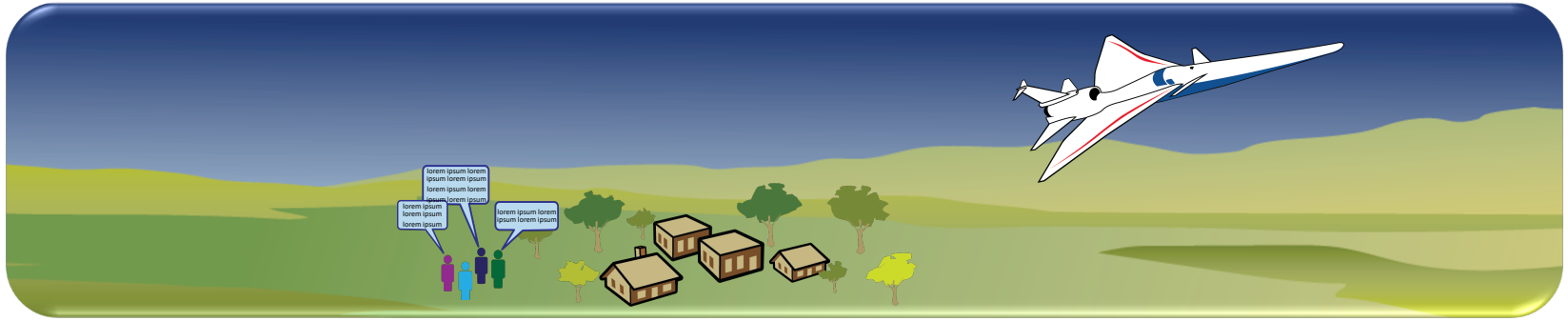
- **Communicate the current status and overall plans for community testing**
- **Provide technical details on the intended approaches for:**
  - Obtaining survey data
  - Characterizing boom exposure
- **Obtain feedback from attendees both during and after the Workshop**
- **Identify any significant concerns regarding the suitability of the proposed community response dataset as the basis for international regulations**

Agenda – Day 1

Monday December 13, 2021 at 8-11 AM EST (GMT-5)				
Start	**End**	**Duration (min)**	**Topic**	**Presenter**
8:00 AM	8:15 AM	15	**Introduction and Workshop Goals**	L. Ozoroski
8:15 AM	8:30 AM	15	**Low Boom Flight Demonstration (LBFD) Mission Overview**	P. Coen
8:30 AM	8:50 AM	20	**LBFD Community Testing Overview**	G. Shah
8:50 AM	9:00 AM	10	**FAA Perspectives**	S. Liu
9:00 AM	9:10 AM	10	**Summary of Key Previous Efforts**	A. Loubeau
9:10 AM	9:20 AM	10	**Break**	
9:20 AM	9:35 AM	15	**Previous Feedback to NASA**	J. Rathsam
9:35 AM	10:35 AM	60	**Open Discussion**	All
10:35 AM	11:00 AM	25	**Summary of Day 1 and Preparation of Day 2**	G. Shah

Agenda – Day 2

Tuesday December 14, 2021 at 8-11 AM EST (GMT-5)				
Start	**End**	**Duration (min)**	**Topic**	**Presenter**
8:00 AM	8:15 AM	15	**Day 2 Introduction**	L. Ozoroski
8:15 AM	8:35 AM	20	**Survey Design & Analysis and Test Site Selection**	J. Rathsam/G. Shah
8:35 AM	9:35 AM	60	**Open Discussion of Survey and Site Selection Topics**	All
9:35 AM	9:45 AM	10	**Break**	
9:45 AM	10:00 AM	15	**Exposure Design and Estimation**	A. Loubeau
10:00 AM	10:45 AM	45	**Open Discussion Of Exposure Topics**	All
10:45 AM	11:00 AM	15	**Workshop Summary**	L. Ozoroski



NASA Community Test Workshop 2

Low Boom Flight Demonstration Mission Overview

Peter Coen

LBFD Mission Integration Manager

NASA Langley Research Center

December 13-14, 2021

NASA Aeronautics

NASA Aeronautics Vision for Aviation in the 21st Century

6 Strategic Thrusts

- Safe, Efficient Growth in Global Operations
- Innovation in Commercial Supersonic Aircraft
- Ultra-Efficient Commercial Transports
- Transition to Alternative Propulsion and Energy
- In-Time System-Wide Safety Assurance
- Assured Autonomy for Aviation Transformation

U.S. leadership for a new era of flight

The vision for commercial supersonic flight

An emerging potential market has generated renewed interest in civil supersonic aircraft

- Evidenced by the appearance of several commercial programs despite lack of standards for en route noise or landing and takeoff noise, emissions

Overland Flight Restrictions based on unacceptable sonic boom noise are viewed as the main barrier to this vision

National Research and Policy agencies play a central role in developing the data needed for the regulation change that is essential to enabling this new market

The vision of the Supersonics Community is a future where fast air travel is available for a broad spectrum of the traveling public.

- Future supersonic aircraft will not only be able to fly overland without creating an “unacceptable situation” but will also be environmentally responsible, affordable and sustainable

Credit :Lockheed Martin

Overcoming the barrier to overland flight

The Low-Boom Flight Demonstration Mission is specifically planned to generate key data for success in NASA's Critical Commitment to support development of en route certification standards based on acceptable sound levels

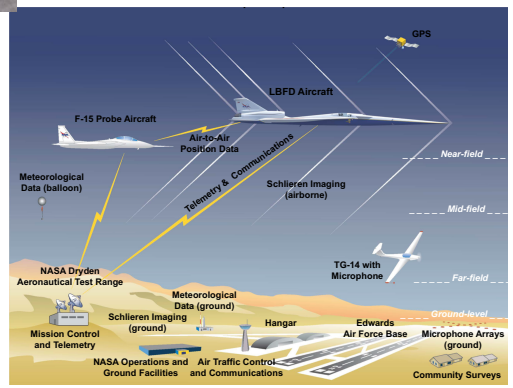
- **New Environmental Standards are needed to open the market to supersonic flight**
- **An En route Noise Standard is the biggest challenge**
  - Requires proof of new design approaches
  - Must replace current prohibitions
  - No relevant data exists to define limits
    - Community data from large, diverse population is a requirement
  - Standard must be accepted internationally

Low Boom Flight Demonstration Mission Overview

Phase 1 – Aircraft Development – *In progress (FY18-23)*

- Detailed design
- Fabrication, integration, ground test
- Checkout flights
- Subsonic envelope expansion
- Supersonic envelope expansion

Systematic Approach Leading to Community Testing



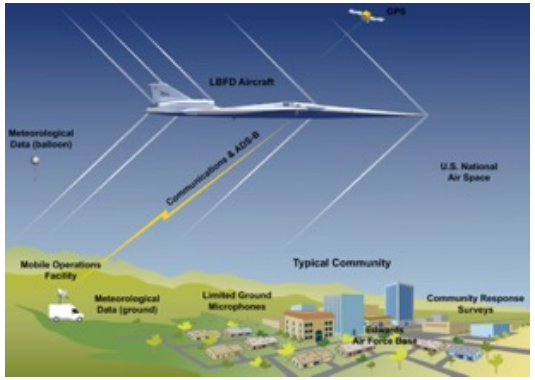
Phase 2 – Acoustic Validation – *Preparation in progress (FY18-23) & Execution FY23-24*

- Aircraft operations & support, range Ops, support aircraft
- In-flight measurement capabilities
- Ground measurement capabilities
- Validation of X-59 boom signature and prediction tools
- Development of acoustic prediction tools for Phase 3

LBFD - Low Boom Flight Demonstrator Project
Integrated Aviation Systems Program

FDC - Flight Demonstrations & Capabilities Project
Integrated Aviation System Program

CST - Commercial Supersonic Technology Project
Advanced Air Vehicles Program

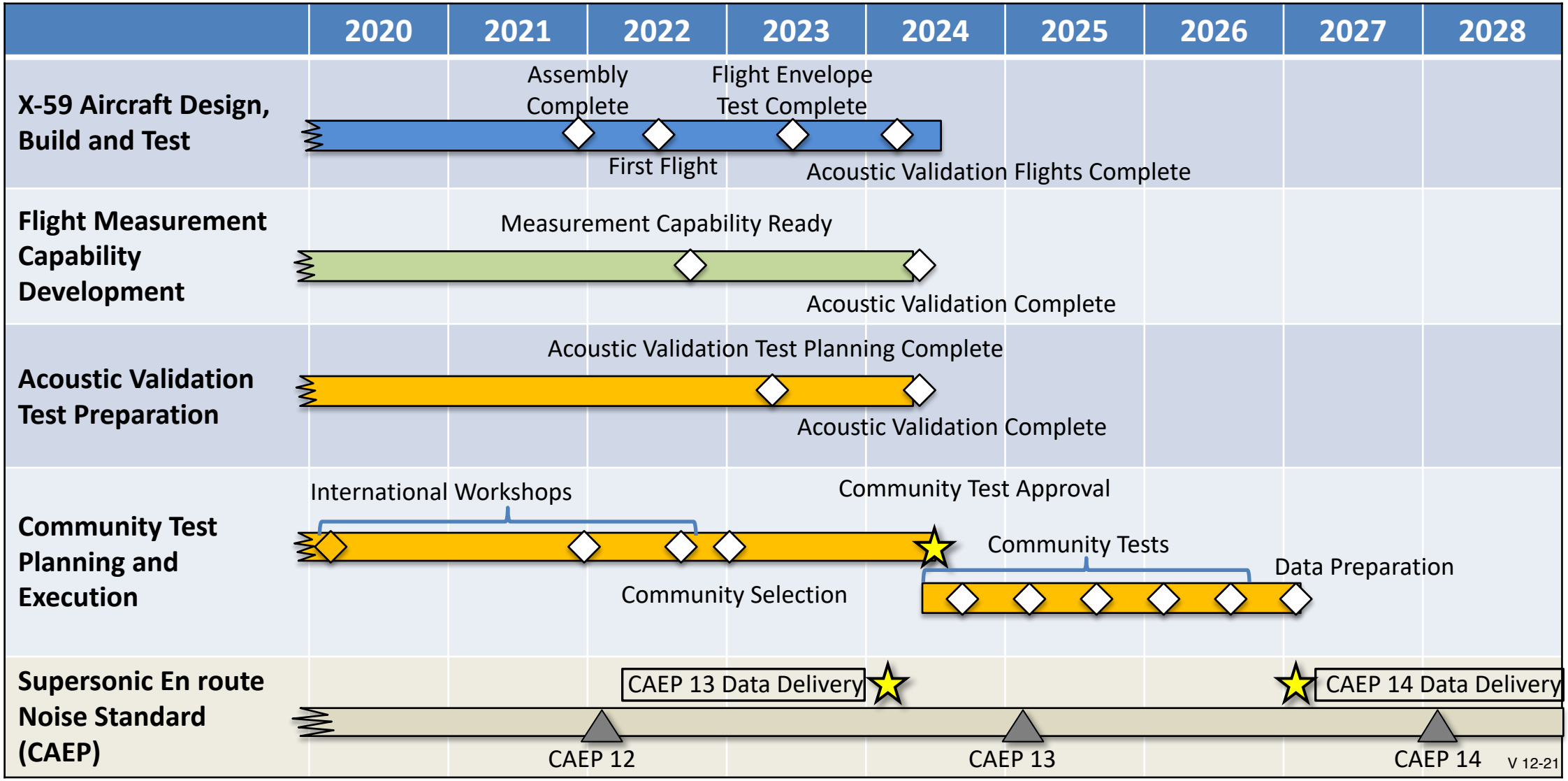


Phase 3 – Community Response Testing

Preparation in progress (FY19-24), Execution FY24-26

- Aircraft operations & support, deployment logistics
- Ground measurement capabilities
- Ground crew operations
- Noise exposure design
- Community response surveys
- Data analysis and database delivery

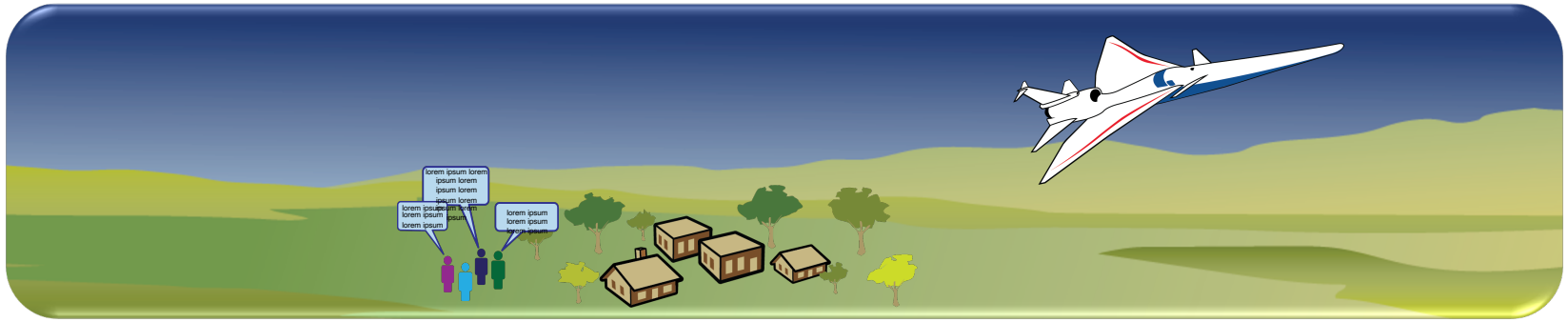
LBFD mission timeline



Concluding remarks

- NASA's Strategic Plan for Aeronautics calls for leadership in Innovation in Commercial Supersonic Flight
- Near-term focus in on overcoming the technical and regulatory barriers to quiet supersonic flight over land
  - Critical Commitment to deliver data to ICAO on community response to quiet overflight sounds
- The development of a new supersonic X-plane is the core of the NASA's Low Boom Flight Demonstration Mission
  - Coordinated development of tools, test hardware and methodology is key to success
- Planning for community overflight tests is underway
  - NASA seeks to engage the international community to insure broadest applicability of data

Welcome to the Workshop!
NASA is excited to share our plans and looks forward to your participation



NASA Community Test Workshop 2

LBFD Community Testing Overview

Gautam Shah
Community Test Planning and Execution Sub-Project Manager
NASA Langley Research Center

December 13-14, 2021

Approach to Meeting Critical Commitment

NASA ARMD Thrust 2 Critical Commitment:

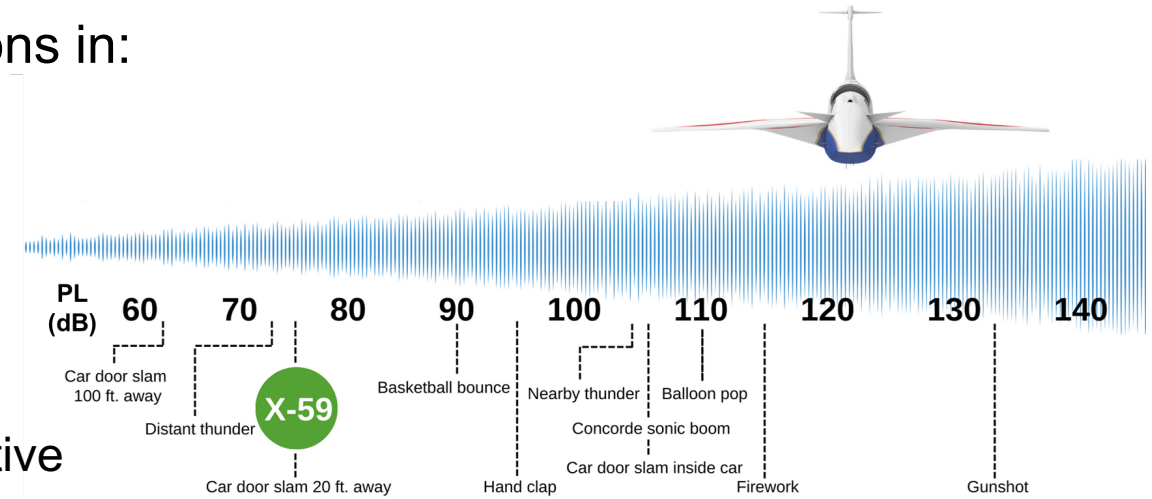
Deliver to ICAO a database of community response to quiet supersonic aircraft flight over land

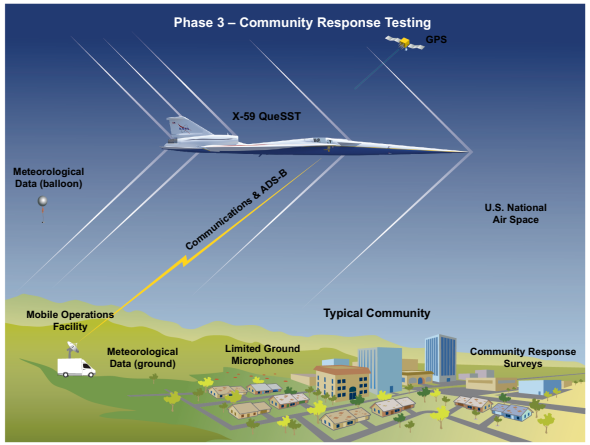
- Develop survey design and statistical analysis methods to quantify sonic boom annoyance levels
- Develop experimental and prediction methods to estimate sonic boom exposure over a large area
- Develop large-scale geolocation methods and means to correlate with annoyance and exposure
- Plan and execute X-59 overflight tests over large non-experienced communities across the U.S.
  - Acquire survey data
  - Acquire acoustic data and estimate exposure levels
- Correlate survey and exposure data to establish dose-response relationship
- ***Provide nationally-representative dose-response database to ICAO for CAEP14***

LBFD Mission Phase 3 – Community Response Testing

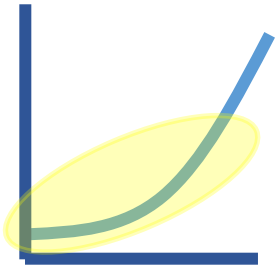
FOCUS: Provide data to support noise certification standards development

- 4-6 community tests over multiple sites, w/ variations in:
  - Climate zones
  - Population demographics
  - Urbanization levels
- Scope
  - Daytime/waking hours
  - Range of exposure levels, single-event and cumulative
  - Community response representative of general population





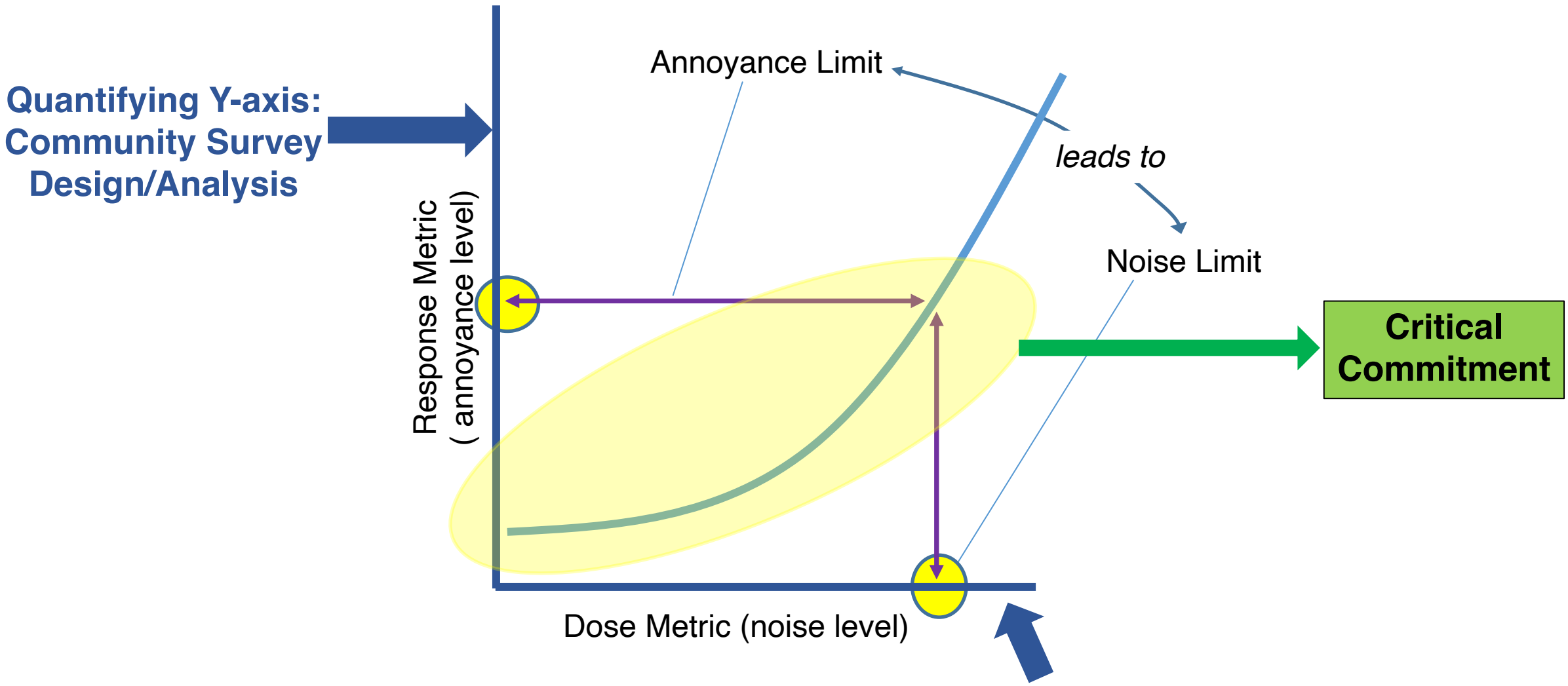
- **Exposure Estimation**
- **Community Surveys**



Dose-Response Relationship

ICAO CAEP 14

Dose – Response Characterization

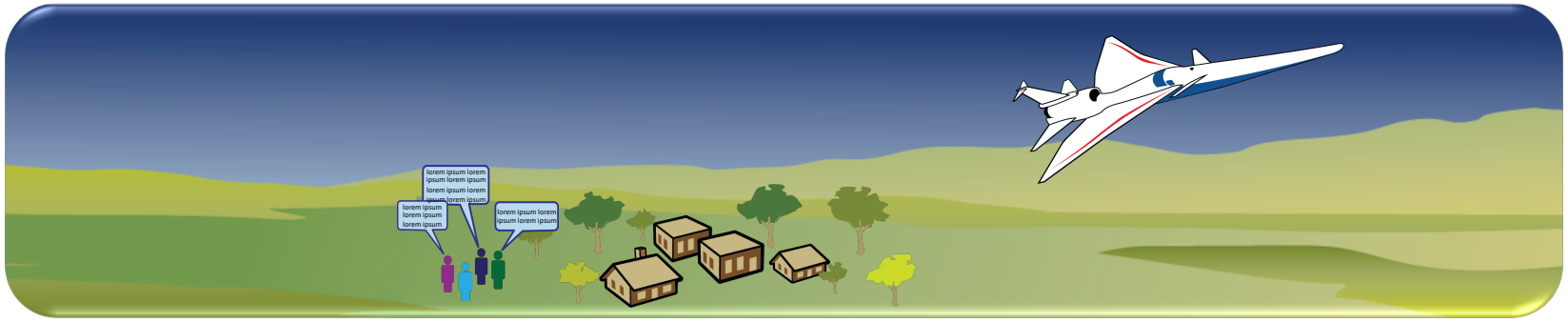


Community Testing – Key Activities

- **Test site selection**
  - Ensure representativeness
  - Deployment coordination/logistics
  - Public engagement
- **Survey Design and Analysis**
  - Participant recruitment
  - Data analysis/statistical methods
  - Test of survey implementation, automated data processing methods
- **Exposure Design and Estimation**
  - Acoustic monitor placement strategies
  - Recording and extraction of signature
  - Characterization of carpet over test area (combining prediction and measurements)
- **Developing Dose-Response Relationship**
  - Matching exposure levels with participant location
  - Aggregating of multiple community test results

LBFD Mission Phase 3 Overall Timeline

2020	2021	2022	2023	2024	2025	2026	2027
Planning Stage				***Execution Stage***			
• Develop overall LBFD Phase 3 plans ○ Survey design ○ Exposure estimation ○ Operations ○ Public outreach and communication • Risk reduction activities ○ Survey test ○ Acoustic monitor and infrastructure checkout ○ Automated data processing validation • Obtain feedback on survey methods and exposure estimation approaches ○ ICAO WG1 participation ○ Virtual and in-person international workshops ○ Independent review panel				• Community Test 1 near AFRC • Additional community tests ○ Various regions ○ Participant demographics • Survey and exposure data analysis • Develop dose-response relationship • Aggregate analyses and extend to nationally-representative database			***Database delivery for CAEP14***



NASA Community Test Workshop 2

Summary of Key Previous Efforts

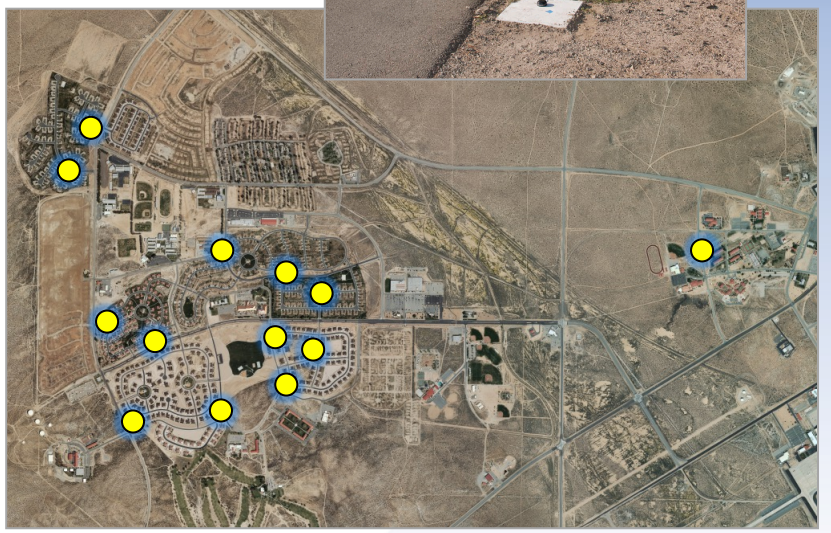
Alexandra Loubeau

NASA Langley Research Center

December 13-14, 2021

Pilot Study (WSPR)

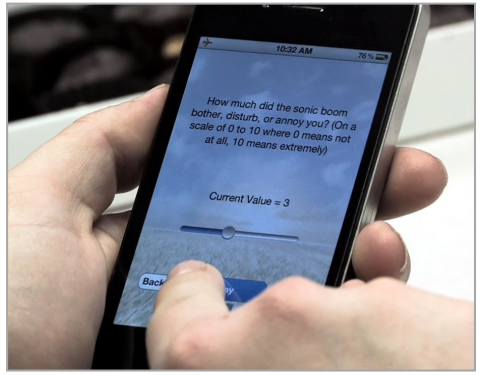
- **Conducted over 2 weeks at Edwards Air Force Base housing area, CA, USA (2011)**
  - Range of boom amplitudes and number of booms/day (100 booms total)
  - Small, isolated community accustomed to sonic booms
- **Developed experimental methodologies**
  - Multiple recruitment techniques explored (incentives effective)
  - NASA F-18 low-boom dive maneuver reliably created booms of varying intensities
  - Sonic boom data acquisition techniques proved effective and robust
  - Subjective methods were successful (paper, website, smartphone)
- **Results used to design QSF18 experimental protocols**



Page et al., Waveforms and Sonic Boom Perception and Response (WSPR): Low-boom community response program pilot test design, execution, and analysis, NASA/CR-2014-218180.

Risk Reduction Test (QSF18)

- **Low-amplitude sonic boom community test in Galveston, Texas, USA (2018)**
  - Test methodologies in a city not used to hearing sonic booms
  - Low-boom dive maneuver
    - 4 - 8 “sonic thumps” daily (52 total) over 1.5 weeks
- **Evaluated updated experimental methodologies**
  - 500 members of public recruited to participate in survey
    - Background, single event, and daily surveys on a website
  - 25 noise monitors set up to measure sound levels in survey area
    - Remote operation, weather robust
  - Public engagement
- **Lessons learned**
    - Methods and planning
    - Test execution
    - Data analysis



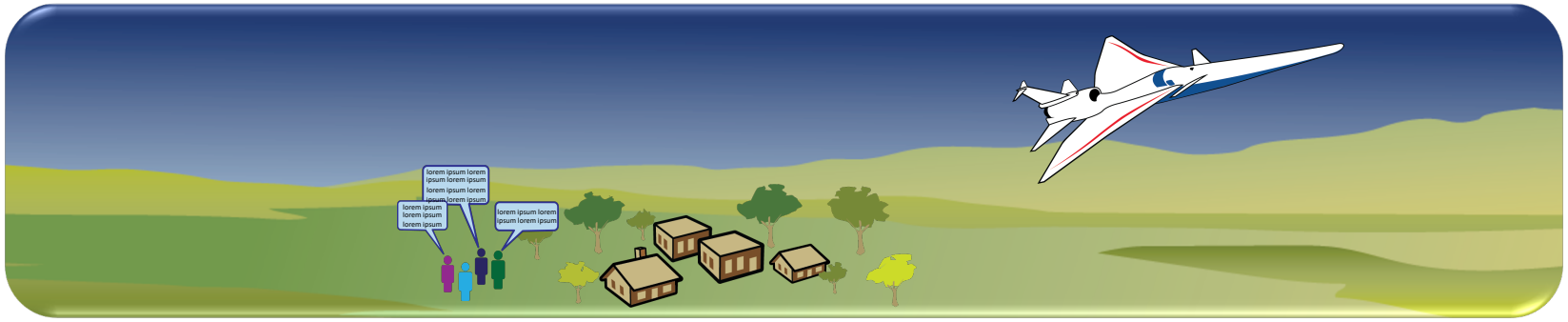
Noise Monitor Locations in Galveston

X-59 Community Test – Expansion of Recent Studies

	WSPR 2011	WSPRRR 2017	QSF18 2018	X-59 2024-26
Research Goal	Pilot Study	Risk Reduction	Risk Reduction	Data for Regulators
Aircraft	F-18	F-18	F-18	X-59 QueSST
Location	AFRC/EAFB	AFRC/EAFB	Non-NASA	Non-NASA (multiple)
Acoustic Data Coverage (sq mi)	1	12	60	~2500
Number of survey participants	100	61	500	~10K
Number of flight days	10	3	9	20-30

Key Challenges of Scaling Up for X-59

- **Non-NASA locations**
  - X-59 operations infrastructure
  - Expanded public outreach
  - Flight planning / airspace coordination
- **Survey design/management**
  - Multi-thousands of participants
  - Aggregation/geolocation of responses
  - Automation of data processing
- **Acoustic measurements**
  - Land use / approvals
  - Hardware robustness and security
  - Remote operation/data transmission
  - Communications connectivity/reliability
  - Automation of data processing



NASA Community Test Workshop 2

Previous Feedback to NASA

Jonathan Rathsam

Community Test Technical Lead: Survey Design and Analysis

NASA Langley Research Center

December 13-14, 2021

Questions asked by NASA at previous workshop

- **Noise Exposure Estimation**
  - What techniques can be used to minimize ambient noise contamination of sonic boom recordings?
  - How accurately do you need to resolve participant locations?
  - What techniques can be used to combine measurements and simulations to estimate dose?
- **Participant Recruitment**
  - What demographic characteristics should be considered for the community response data to be representative?
  - How should demographics be incorporated into the recruitment process?
  - What is the impact of using the same pool of participants for both single event and cumulative surveys vs. using different pools of participants?
- **Survey Design and Analysis**
  - NASA is planning to administer single event and cumulative daily surveys during month-long X-59 community response tests. Is this test duration adequate?
  - What techniques are needed to combine data from multiple tests into nationally representative results?
  - What survey data would be appropriate for setting international standards?

- **NASA received valuable feedback during and after the workshop, which has helped in development of test plans.**

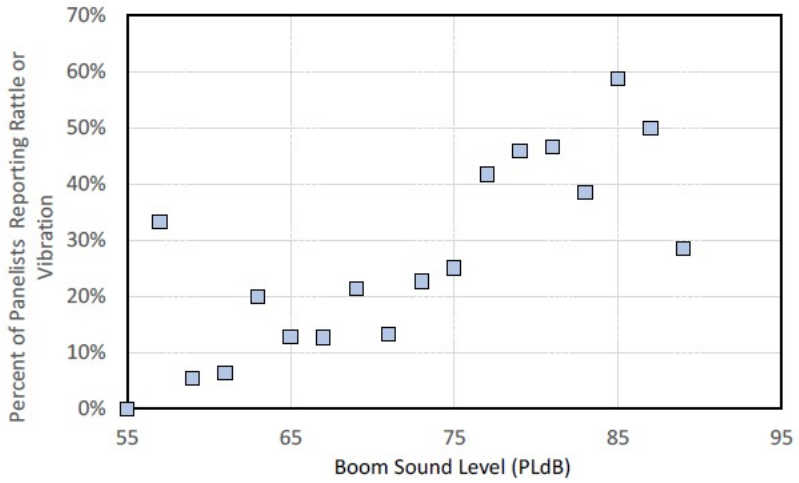
Additional questions received by NASA

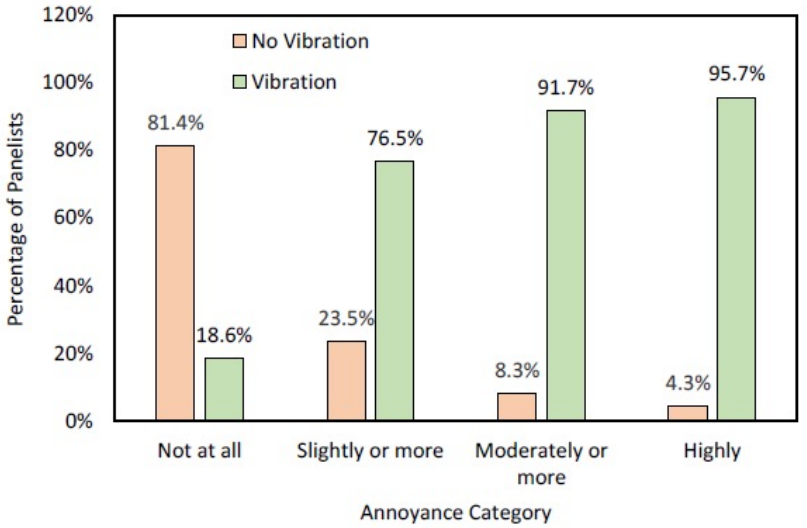
How will NASA address the following topics?

- **Building effects**
  - Rattle
  - Construction type and rattle
  - Windows open/closed
- **Nighttime flights**
  - Effect of quiet supersonic flight on sleep, effects of rattle on sleep
- **Ambient noise**
  - Test in rural environments as well as cities
- **Past experience with sonic booms among survey participants**
- **Risk of avalanche**

How will NASA address building effects?

- **NASA Response: Building effects will be addressed via survey questions. No building measurements are currently planned.**
  - Survey questions on vibrations and rattle enable analyses such those shown on the right.
  - Survey questions regarding building type and whether windows are open or closed to address possible associations between these variables and annoyance
- **Relevant Literature**
  - Indoor sonic boom exposure varies with building construction type.
    - Stiffer, heavier building materials are associated with less vibrations and rattle than lighter building materials.
  - Vibrations and rattle are associated with increased annoyance indoors
  - Indoor sonic boom exposure varies when windows are open vs. closed





Fidell, et al. 2020 https://ntrs.nasa.gov/citations/20205005471

How will NASA address effects of nighttime flights?

- **NASA Response: The scope of the community testing is daytime or "waking" hours, and does not include studies of the effects of nighttime flights**
  - Scope reflects achievable capability during CAEP14 timeframe
  - Consideration of logistics and flight capabilities/safety of experimental aircraft ops in public airspace
  - However, community test overflights in the evening hours after sunset may occur in later tests

How will NASA address effects of ambient noise?

- **NASA Response: NASA's plans address possible effects of ambient noise using population density as a surrogate measure.**
  - NASA plans to select test sites that are nationally representative in terms of population density (urban vs. rural), among other factors.
  - Post-hoc statistical analyses will address effects of population density on community response.
  - More information on Test Site Selection will be presented on Day 2.

- **Relevant Literature**
  - The effects of ambient noise on community response to transportation noise are not fully understood. Some studies suggest ambient noise is related to community response, while other studies suggest it is not.
    - No studies currently exist on effects of ambient noise on community response to quiet supersonic overflights.
  - Ambient noise correlates with population density.

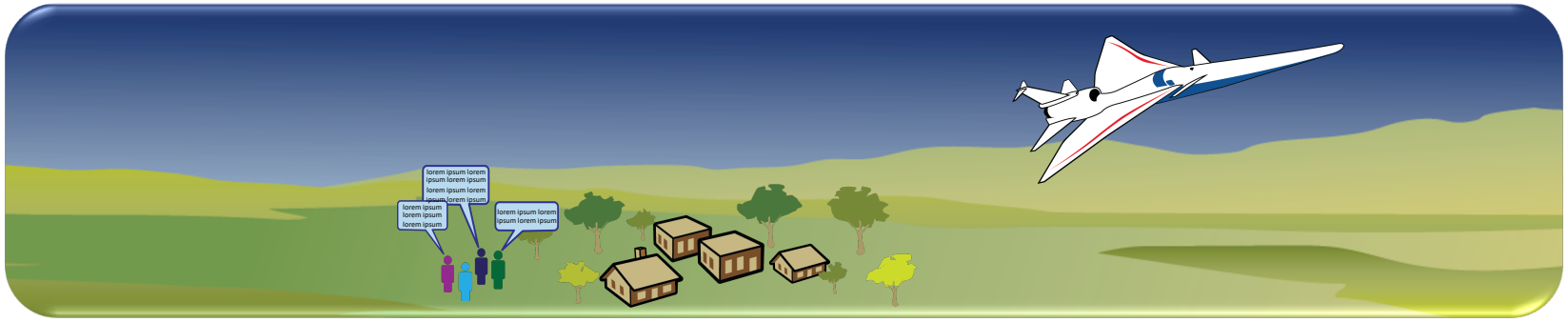
How will NASA address past experience with sonic booms?

- **NASA Response: NASA's plans are not specifically addressing this research topic. Test sites are intended to be locales that are not acclimated to hearing sonic booms.**
  - Avoid direct comparisons between sonic thumps and sonic booms.
  - Familiarity with sonic booms is not common in the general population.

How will NASA address the risk of snow avalanches?

- **NASA Response: NASA's plans are not specifically addressing this research topic.**
  - X-59 sonic thump levels are much lower than levels recorded in a study described below

- **Relevant Literature**
  - Lillard et al. 1965 https://apps.dtic.mil/sti/pdfs/AD0468794.pdf
  - 18 supersonic overflights were flown over an area prone to snow avalanches.
  - Overflights resulted in measured overpressures from 1.15 to 5.02 psf.
  - No avalanche activity was generated by supersonic overflights.
  - Although other avalanches were observed in the area during testing, Forest Service personnel rated the avalanche hazard as low during the test period. It was recommended to repeated the testing during periods of high avalanche hazard.



NASA Community Test Workshop 2

Survey Design and Analysis

Jonathan Rathsam

Community Test Technical Lead: Survey Design and Analysis

Gautam Shah

Sub-Project Manager: Community Test Planning & Execution

NASA Langley Research Center

December 13-14, 2021

Survey Goals

Primary Goals

- Develop an accurate nationwide estimate of the **single-event** dose-response relationship between the proportion of the population annoyed (to varying degrees) by supersonic overflights and acoustical data (measured and modeled) that characterize single-event noise exposure.
- Develop an accurate nationwide estimate of the **cumulative** dose-response relationship between the proportion of the population annoyed (to varying degrees) by supersonic overflights and acoustical data (measured and modeled) that characterize cumulative noise exposure.

Secondary Goals

- Assess the effect of indoor **noise-induced rattle sounds and vibration** on dose-response relationships
- Assess the effect of **location** (home vs. work. vs. somewhere else, indoor vs. outdoor, and indoor with windows open vs. closed) on dose-response relationships.
- Assess the effect of **time-of-day** on sonic thump perceptions (daytime vs. evening).
- Assess the prevalence of **"startle"** in sonic thump perceptions.

Key Milestones for Survey Design and Analysis

- **Survey Methods Developed**
  - Literature review, questionnaires, sample size determination, recruitment plan, recruitment materials
- **Data Analysis Techniques Developed**
  - Automated methods to match survey responses with location, methods for fitting statistical models
- **Institutional Review Board Approval**
  - Ensures ethical treatment of test participants
- **Paperwork Reduction Act Clearance Approval**
  - U.S. governmental review of surveys involving members of the public to ensure no undue burden
- **Survey Test Executed (Fall 2022)**
  - Conduct a full survey test on members of the public for 30 days (no overflights)
  - Assess response rates, test survey instruments (mobile app and web), test methods for locating participants, test survey questions

Same or Different Pools of Participants for Different Surveys

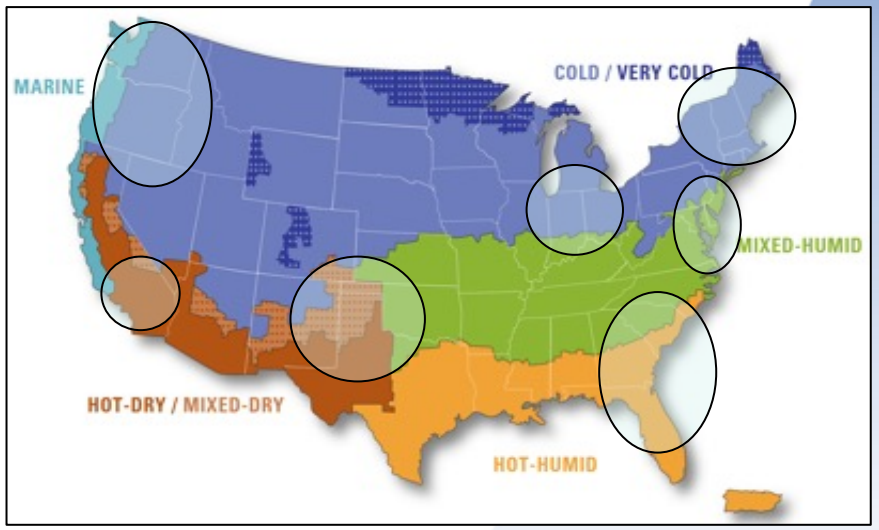
- **Update on question from first workshop:** What is the impact of using the same pool of participants for both single event and cumulative surveys vs. using different pools of participants (in each community test)?
- **NASA plans to use the same pool of participants for both single event and cumulative surveys.**
- **Rationale:**
  - Enables use of daily survey for location information unable to be obtained using the singe event survey
  - Enables larger sample sizes relative to spreading the sample across two surveys, resulting in potentially higher precision in estimates
  - Enables joint analysis of the single-event and cumulative surveys
  - Reduces complexity in survey materials and procedures, including mobile phone app programing
- **Mitigations for possible drawbacks of using the same pool of participants:**
  - Potential confusion about the differences between single-event and cumulative surveys will be mitigated via clear instructions on the differences and why it is important to fill out both
  - Additional respondent burden will be mitigated via an incentive structure that encourages respondents to fill out both surveys

Intended Uses for Dose-Response Curves

- **Single-event dose-response curve directly informs Standards and Recommended Practices (SARP) noise limit**
- **Cumulative dose-response curve does not directly inform SARP noise limit, however it:**
  - Describes community response to more realistic future supersonic operations with multiple daily overflights.
  - Enables comparison with existing social survey data (both community response to high-energy impulsive sounds, and other transportation noise sources)
- **Is either dose-response curve a higher priority than the other?**
  - It may not be possible to simultaneously optimize experimental design for both curves.
  - Is the single-event dose-response curve higher priority because of direct link to SARP?
- **Examples from the literature where a linkage is made successfully between single-event exposure levels and response to cumulative exposure?**
  - McCurdy et al. 2004 https://asa.scitation.org/doi/10.1121/1.1781189
  - Fidell 2013 https://asa.scitation.org/doi/abs/10.1121/1.4800416

Community Test Site Selection

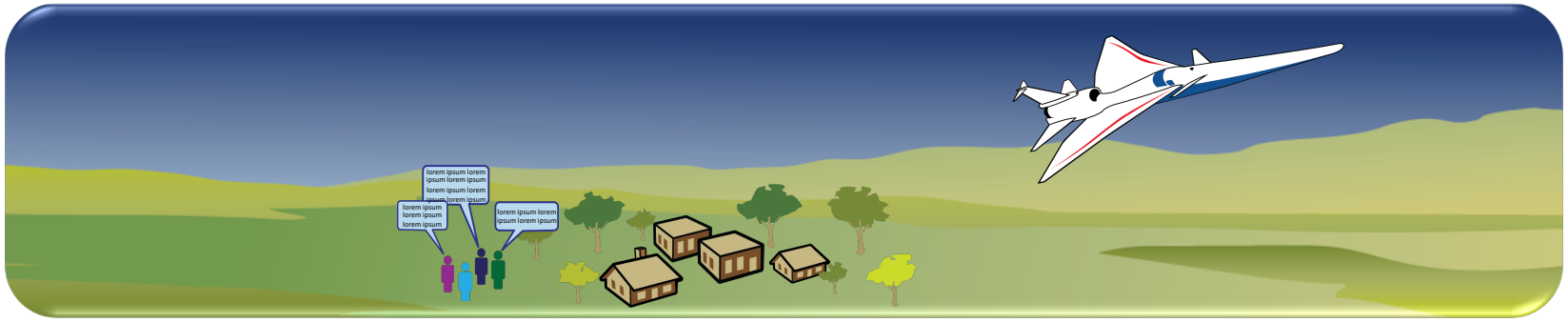
- **4-6 Tests planned for 2024-2026**
  - Test #1 from NASA Armstrong Flight Research Center (Southern California); test site TBD
  - Subsequent test airfields and locations TBD; evaluation/selection process is ongoing
- **Technical and aircraft-related constraints, e.g.,**
  - Runway requirements, airfield infrastructure, emergency/alternate landing sites
  - Available population centers, focus boom placement
- **Challenges to ensuring representativeness of test communities to overall US**
  - Sampling approaches and statistical validity
  - Randomization or other methods to select from viable candidate locations?
  - Geographic and climate zone variation
    - Climate influence on range of thump levels
    - Addresses housing construction diversity?
  - Participant demographic diversity – gender, age, ethnicity, etc.
  - Variation in urbanization level



Example of geographic and climate zone options

Survey Design and Analysis Discussion Topics

- **Is either dose-response curve (single-event or cumulative) a higher priority than the other?**
  - Is the single-event dose-response curve higher priority because of the direct link to SARP?
- **Examples from the literature where a linkage is made successfully between single-event exposure levels and response to cumulative exposure?**
- **NASA is planning to administer single event and cumulative daily surveys during month-long X-59 community response tests. Is this test duration adequate?**
- **NASA Questions from Previous Workshop**
  - What demographic characteristics should the sample of survey participants have to be considered nationally representative?
  - How should demographics be incorporated into the recruitment process?
  - What is the impact of using the same pool of participants for both single event and cumulative surveys vs. using different pools of participants?
  - What techniques are needed to combine data from multiple tests into nationally representative results?
  - What survey data would be appropriate for setting international standards?



NASA Community Test Workshop 2

Exposure Design and Estimation

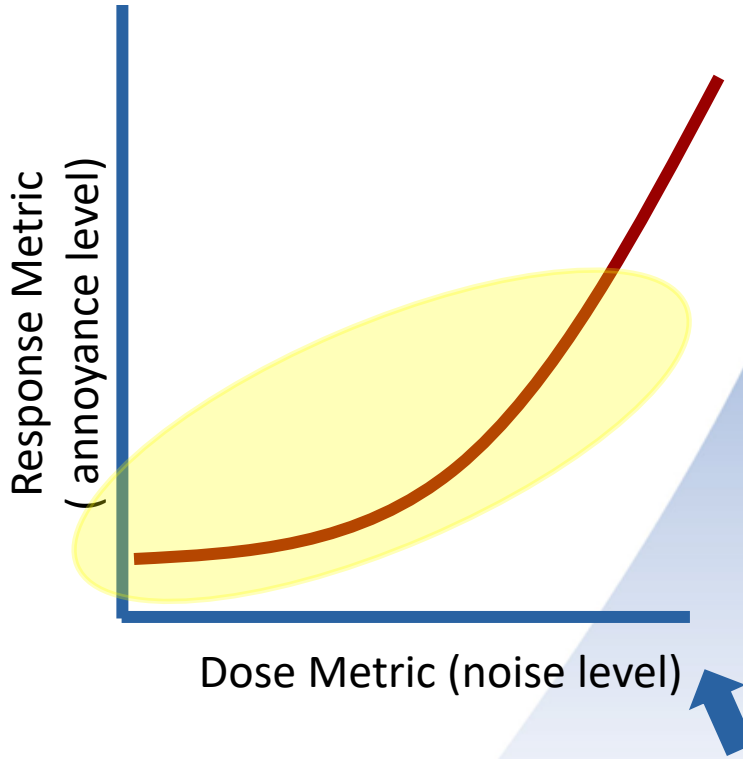
Alexandra Loubeau

NASA Langley Research Center

December 13-14, 2021

Introduction

- **Exposure design**
  - Range of doses
  - Dose distribution
  - Test length
- **Develop experimental and prediction methods to estimate sonic thump exposure over a large area**
  - Measure sonic thump levels at the ground across the community
  - Simulate sonic thump levels post-flight using test day flight and weather data
  - Estimate sonic thump levels at participant locations during overflights using measurements and predictions
  - Use these estimates as noise dose for dose-response curve



Quantifying X-axis: Exposure Design and Estimation

Exposure Design

Range of doses

- Both single-event and daily dose are being considered
- Limited by X-59 operational constraints
  - NASA studies on range of levels expected in real atmospheres across U.S.
- Single-event exposure design will target 15-20 dB range around X-59 cruise design point of PL = 75 dB
  - PL ~ 70-87 dB
- Resulting cumulative dose range (1-6 thumps per day)
  - PLDNL ~ 20-45 dB

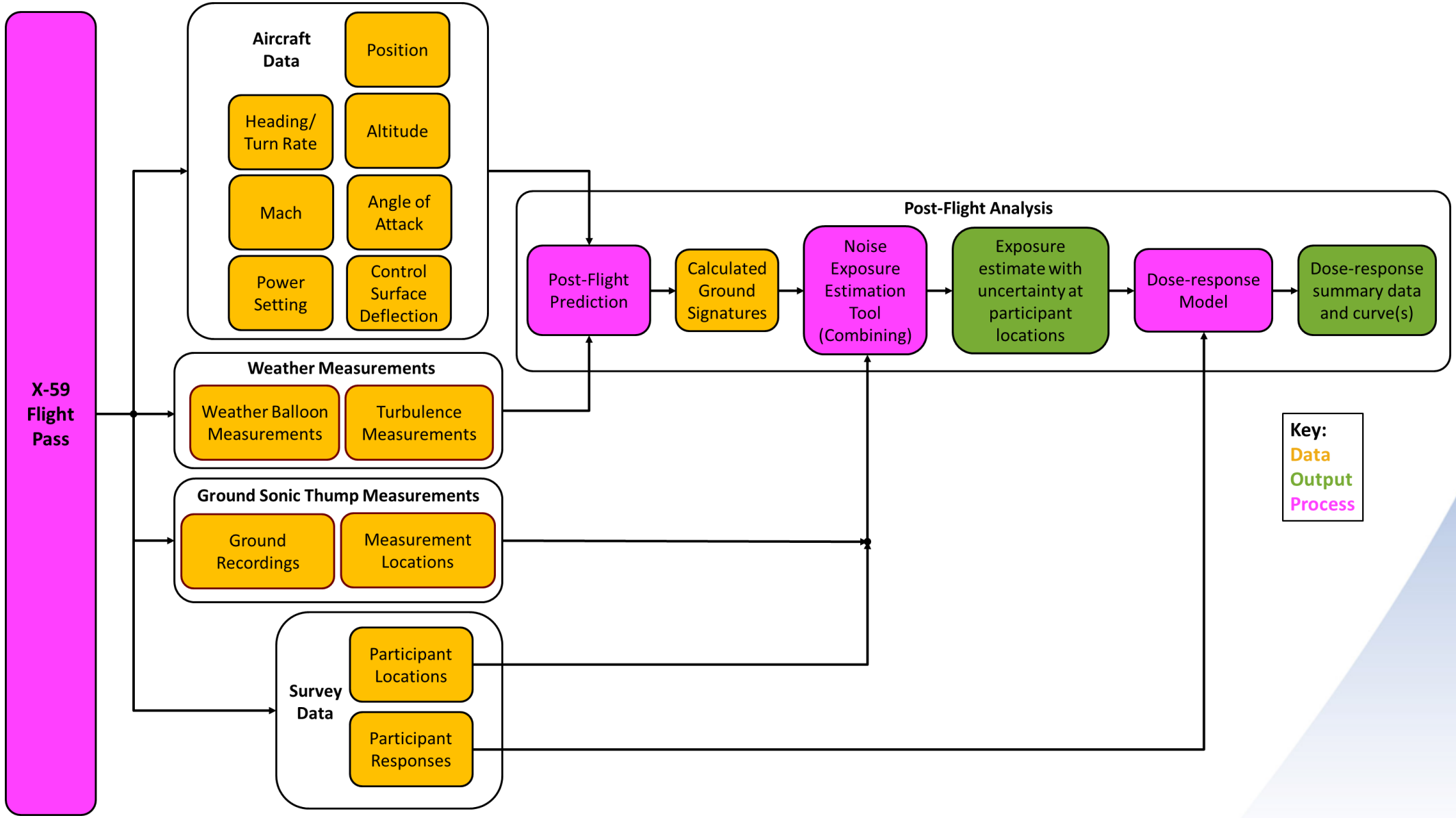
Dose distribution and scheduling

- Design allows for varying levels and number of events to achieve desired range and distribution
- Times of day and weekdays/weekends will also be randomized
  - Spacing of at least 20 minutes
- 80-90 thumps per community test

Test length

- ~20 flight days over one month

Post-flight Exposure Estimation Process



Key Challenges

- Estimating exposure level across large survey areas
- Estimating meteorological conditions across survey area
- Automation of acoustic data acquisition and exposure estimation methods to support X-59 deployment pace
- Mitigating background noise in recordings
- Acoustic sensor placement strategy

- **Strategy to address challenges includes testing methods during LBFD Phase 2**
  - Hardware/software testing
  - Validation of remote operation and robustness
  - Testing of rapid automated methods

Noise Monitors

- Weather-robust and portable
- Capable of ground-level and elevated mic configurations
- Support remote operation
- Low-frequency system response down to 1 Hz
- Sampling rate of 51.2 kHz with 24-bit ADC
- Automatic triggering and on-board signal processing software

Sonic Thump Noise Monitor Concept

Noise Monitor Placement Strategy

- **Analysis using simulation datasets has led to set of recommendations**
- **Clustering of noise monitors and averaging their levels**
  - Clusters of five monitors at ~30 sites
  - Reduce spatial correlation by spacing monitors ~200 m apart
  - Improves dose estimate in presence of atmospheric turbulence
  - Reduce effects of ambient noise
- **Method for mitigating ambient noise effects developed**
- **Method for extracting sonic thump from acoustic recording developed**
- **Methods for combining predicted and measured noise dose under development**

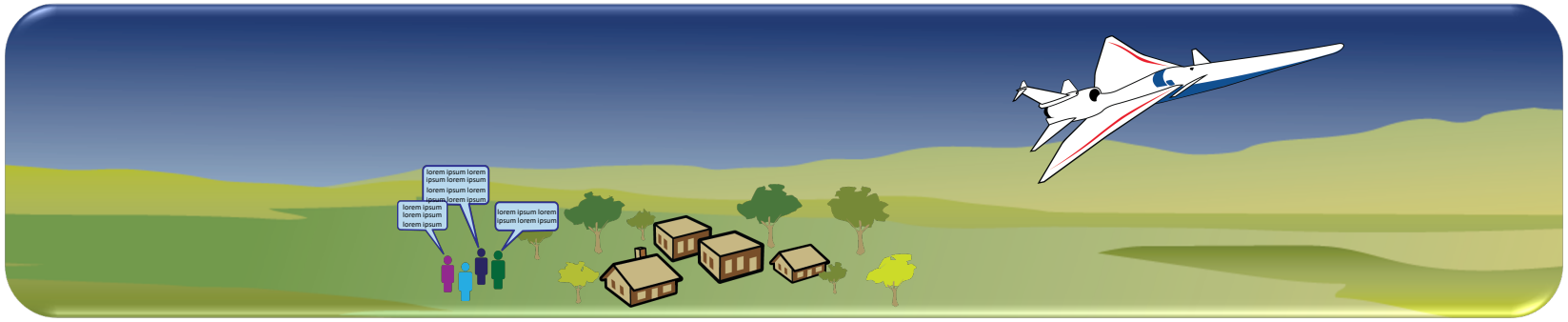
Jacob Klos. Recommendations for using noise monitors to estimate noise exposure during X-59 community tests. NASA/TM–2020-20205007926.

Exposure Design & Estimation Discussion Topics

- What methods could mitigate effects of atmospheric turbulence on dose estimation?
- What methods could be used to combine predictions and measurements?
- How should uncertainty be incorporated in dose estimation?

- What resolution of atmospheric measurements would be sufficient?
- Are atmospheric turbulence measurements needed, and at what resolution?

- What is the relative importance of single event vs. cumulative daily levels in exposure design?
- What cumulative exposure metrics should be used?



NASA Community Test Workshop 2

Summary

Lori Ozoroski

Commercial Supersonic Technology Project Manager

December 13-14, 2021

Workshop Goals

- **Communicate the current status and overall plans for community testing**
- **Provide technical details on the intended approaches for:**
  - Obtaining survey data
  - Characterizing boom exposure
- **Obtain feedback from attendees both during and after the Workshop**
- **Identify any significant concerns regarding the suitability of the proposed community response dataset as the basis for international regulations**

Key Topics Discussed

General Topics (mostly from Day 1)

- Test considerations – days of the week, seasons, etc.
- Relevance/importance of an international test; requirements/timeline
- Additional collaboration during X-59 tests
- Rumble recommendations for community tests
- How community engagement/informing will be done
- Acoustic/non-acoustic factors?
- Regulators' data requirements/needs?
- Use of X-59 for certification procedures development
- XVS use for requirements/certification work?
- Critical attention-focused tasks impacted by thump levels?

Survey Design and Analysis and Site Selection Topics

- Scope of test duration
- Influence of open/closed window; related to season, housing construction types
- Age-appropriate options for responding to survey
- Approach to notifying survey participants pre- and post-flyover
- Site Selection
  - Inclusion of first community test to overall results and timeframe to incorporate lessons learned into future tests
  - LTO considerations in airfield/test site selection
  - Terrain variations influence on site selection
  - Urbanization level/ambient noise influence on site selection
  - Ensuring representativeness of low-income demographics wrt lack of internet/mobile access
- Significant discussion on representativeness aspects
  - Key factors to consider/include in participant pool for broad representativeness
  - Survey requirements (# of people, etc.) to ensure statistical representativeness to a large population
  - How can survey be designed to better reflect responses in other countries
  - Significance of representativeness of US versus representativeness of the world in general
- Use of single-event versus cumulative results for different aspects, e.g., SARP, acceptable sound limits for public
- Determination of metrics to be used during testing

Noise Exposure Design and Estimation Topics

- Noise exposure scheduling
  - QSF18 experience used to inform exposure scheduling?
  - Range of PL dose level with X-59
- Measuring near and mid-field characteristics, not just at ground level
- Focus booms – acceleration/maneuvering
- Extent of carpet that will be covered beyond undertrack
- How to address turbulence in noise estimation
  - Leverage of NOAA experience on grid resolution
  - Measuring atmospheric boundary later thickness
- Uncertainty considerations
  - Levels expected, both modeled and measured – single event and daily cumulative
  - Experience from QSF18 on uncertainty in measurements
- Measurements of secondary sonic booms?
- How to address ambient noise, both for acoustic measurements and in proximity to participant
- Microphone placement considerations, e.g., justifications for current specs on distances, etc. in noise monitor clustering approach
- Considerations of post-boom noise for both exposure estimation and annoyance levels

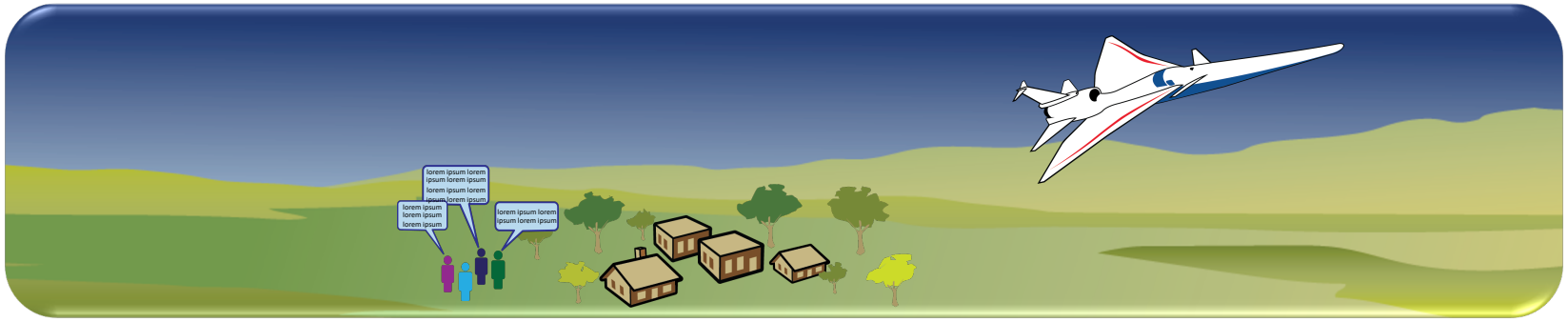
Workshop Follow-up

- NASA is requesting additional feedback from today's participants. Please send correspondence to the email below by Friday, January 7, 2022.

  nasa-community-test-workshop@mail.nasa.gov

- NASA will share a summary of the workshop, as well as its recording, in the near future.

- NASA is planning a follow-on face-to-face workshop in the Fall of 2022. Announcement will be shared with workshop participants when more details become available.



Thank you for your participation!